LANDS DIRECTORATE
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AN EVALUATION OF A METHODOLOGY (SNELL, 1981) FOR DETERMINING PRESETTLEMENT AND EXISTING WETLANDS IN CANADA

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ABSTRACT

In response to the questions of how much wetland exists and how much has been converted to alternate land uses, Snell (1981), developed a methodology to determine existing and lost wetlands in southern Ontario. Using the Canada Land Inventory Soil Capability for Agriculture and Present Land Use maps, Snell was able to derive the Wetland Approximation Mapping Series for delineating lost and existing wetlands in southern Ontario. The successful application of this mapping technique to other regions of Canada would provide a much needed national wetland inventory for resource managers.

This paper examines the applicability of using the Snell methodology in other regions of Canada and tests its application in the provinces of Manitoba and Nova Scotia. A comparison is made between the results obtained by Snell with regard to existing and lost wetlands for the Oshawa area and the data available through the Urban Centred Region program of the Canada Land Use Monitoring Program.

RÉSUMÉ

À partir des cartes de l'Inventaire des terres du Canada sur les possibilités agricoles des sols et l'utilisation actuelle des terres, Snell (1981) a établi une méthode pour calculer, dans le cas des terres humides du sud de l'Ontario, la superficie encore à l'état vierge et la superficie convertie à d'autres usages. En appliquant cette technique de cartographie à d'autres régions du Canada, les gestionnaires des ressources pourraient obtenir un inventaire national des terres humides qui leur serait fort utile.

Ce document examine l'applicabilité de la méthode Snell à d'autres régions du Canada et éprouve son utilisation dans les provinces du Manitoba et de la Nouvelle-Écosse. Il compare les résultats obtenus par Snell pour les terres humides vierges et converties à d'autres usages, dans la région d'Oshawa, avec les données tirées du volet des régions urbaines du Programme de surveillance de l'utilisation des terres du Canada.

PREFACE

This paper is the result of a contract by the Lands Directorate, Environment Canada to determine the applicability to other regions of Canada of the methodology developed by Snell (1981) to detect wetlands in southern Ontario. The contents of this paper result from a review of numerous Canada Land Inventory, soils and other maps at various scales. Time constraints did not permit the review of all available data, and any errors or omissions brought to the Directorate's attention would be most appreciated.

The results of this evaluation form one of several contributions to methodology development research undertaken by the Lands Directorate towards a national overview on wetland conversion in Canada. The project is one element of Prime Wetlands Studies in the Canada Land Use Monitoring Program.

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1.0 INTRODUCTION

Private and public agencies are becoming increasingly concerned about the unmonitored loss of wetlands across Canada. Although extensive in-depth studies have been conducted evaluating and documenting land use change for specific wetlands, national and regional questions concerning how much wetland has been lost and the spatial distribution of the remaining wetlands remain unanswered.

In an effort to respond to these questions, Elizabeth Snell, of the Lands Directorate, and in cooperation with the Canadian Wildlife Service in 1981 undertook to map the existing and lost wetlands across southern Ontario. Using Canada Land Inventory manuscript maps, Snell successfully produced the Wetland Mapping Series (Second Approximation), which presented the current wetland situation across southern Ontario. The successful application of the Snell methodology to detect existing and lost wetlands in other regions of Canada would provide the needed datum from which future land use change or wetlands could be monitored.

Since 1981, finalization of the Ontario Wetland Mapping Series has resulted in 124 maps at 1:50 000 scale. Currently, a Third Approximation of this map series is in preparation to update to 1982. Map digitization is in progress to permit calculation of wetland land use change dynamics with reference to 1982 land use mapping by the Ontario Ministry of Agriculture and Food. However, these results were not available at the time of this evaluation and could not be compared.

It is the objective of this paper to test the application of the 1981 Snell methodology to determine wetlands and wetland loss in regions of Canada external to southern Ontario and also to compare the results obtained by Snell with the data available from a corresponding Urban Centred Region.

The paper consists of two parts; part one is a review of the Snell methodology and its application to test areas in Manitoba and Nova Scotia. Part two deals with the comparison of wetland change data that can be generated in a computerized mode through the Canada Land Data System (CLDS) for the Oshawa Urban Centred Region (UCR) and that determined for the same area, using Snell's (1981) manual overlay techniques.

The evaluation of UCR data bases, it is hoped, will provide a rapid, inexpensive method for reporting on wetland conversions near Canada's major cities. Conversions in these UCR areas are especially significant since they are the wetlands of prime access to most Canadians. They are also under severe stress by urban related developments (Rubec, 1980; Lynch-Stewart, 1983).

2.0 THE SNELL METHODOLOGY (1981) - A REVIEW

2.1 OBJECTIVES

Continuous pressure to drain and convert wetlands to alternate land uses in southern Ontario brought to the forefront the lack of reliable data on the overall distribution of wetlands and the magnitude of wetland loss. In 1981, E. Snell undertook to produce a data set to provide all levels of planning with a spatial appreciation of the current wetlands situation and the approximate locations of wetland loss (Snell, 1982).

A generalized definition of wetlands was adopted for the wetland mapping project:

> "Wetlands are land areas which have soils saturated throughout or almost all of the year which support natural vegetation adapted to those edaphic conditions."
>
> (Snell, 1981)

Two assumptions were made based on the wetland definition:

1) Soils which are described as saturated and are found to support natural vegetation can be identified as wetlands.
2) Soils which are described as saturated, but do not support natural vegetation can be designated as areas of wetland that have undergone land use change.

(Snell, 1981)

2.2 THE METHODOLOGY

Based on the above definition and assumptions, Snell acquired the best existing soils and vegetation cover mapping available for southern Ontario to deterine the spatial distribution of existing and lost wetlands. The Canada Land Inventory (CLI) soil capability for agriculture and present land use mapping series, (scale 1:50 000), were selected on the basis of mapping uniformity, availability, consistency, and year of completion.

CLI soil capability maps were derived from existing Ontario Soil Survey maps (scales ranging from 1:20 000 to 1:126 720). Therefore, it was possible to make a direct correlation between soil capability units and soil survey unit descriptions. It was found that poorly drained and very poorly drained soils (i.e. those fitting the definition of being saturated for all or almost all of the year) corresponded to soil capability polygons limited by wetness. As well, peaty soils correlated with organic soils of CLI. (For a complete review of CLI soil capability classifications and limitations refer to Appendix I).

CLI present land use mapping was undertaken using mid-1960's aerial photography. Of the fifteen land use categories determined (see Appendix II), three describe natural vegetation:

1) T - Mature forest
2) U - Immature forest
3) M - open wetland (marsh, bog, fen)

Using an overlay technique, Snell delineated organic soils and soil capability units limited by wetness and transferred them onto CLI 1965-68 land use maps. Those wet soil and organic areas still in natural vegetation, classes U, T or M, on CLI land use maps were existing wetlands as of 1965-68; those areas no longer in natural

vegetation were wetlands that had been converted to alternate land uses such as agriculture or urban expansion (Figure 1). In addition, any topographic map symbols indicating wetlands not caught by the above overlay procedures, were included. This was most evident along lakeshores, rivers, marsh edges, and on small, inland water bodies.

In summary, data critical to the success of the Snell methodology for determining wetlands are reliable data bases delineating (a) wet and organic soils and (b) land use.

2.3 RESULTS

The Wetland Mapping Series (Second Approximation) consists of 124 1:50 000 map sheets; the series approximates the location of past and present wetlands, present wetland vegetation, and the wet mineral soil capability rating, (Figure 2a,b). Following the completion of the map series, Snell circulated the maps to interested private and public agencies for evaluation and comment. Results were encouraging and positive; wetland boundaries were found to be "fairly accurate" (Snell, 1982) when checked in the field. Revisions through to the final published Second Approximation and Third Approximation have significantly improved this accuracy (Snell, personal communication).

The methodology for determining wetlands used by Snell has proven to be of value. It was not, however, intended to replace detailed wetland mapping, but rather to serve as a means of quickly and inexpensively obtaining interim maps until a more precise mapping could be made available (Snell, 1982).

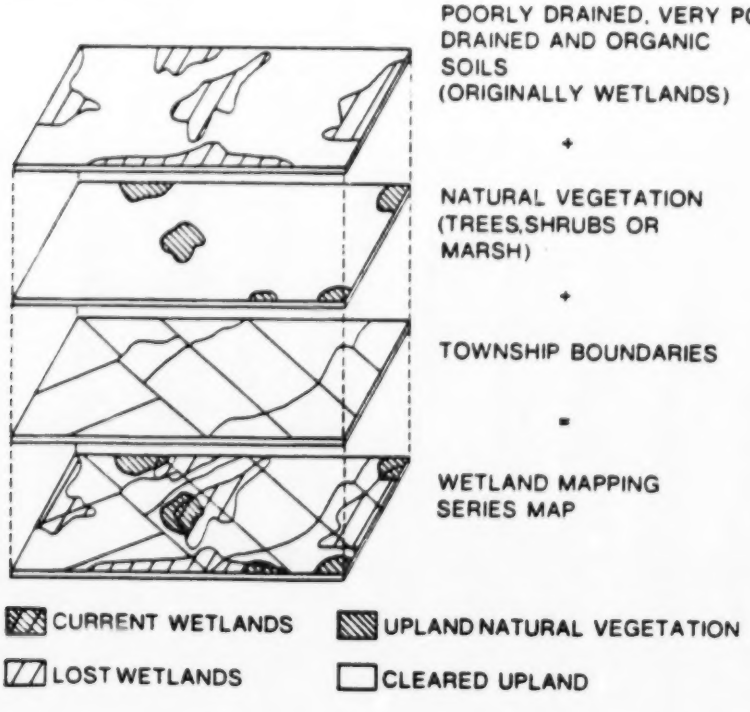


Figure 1: Wetland Mapping Methodology Using Existing Soils and Vegetation Mapping. Source: Snell, 1981.

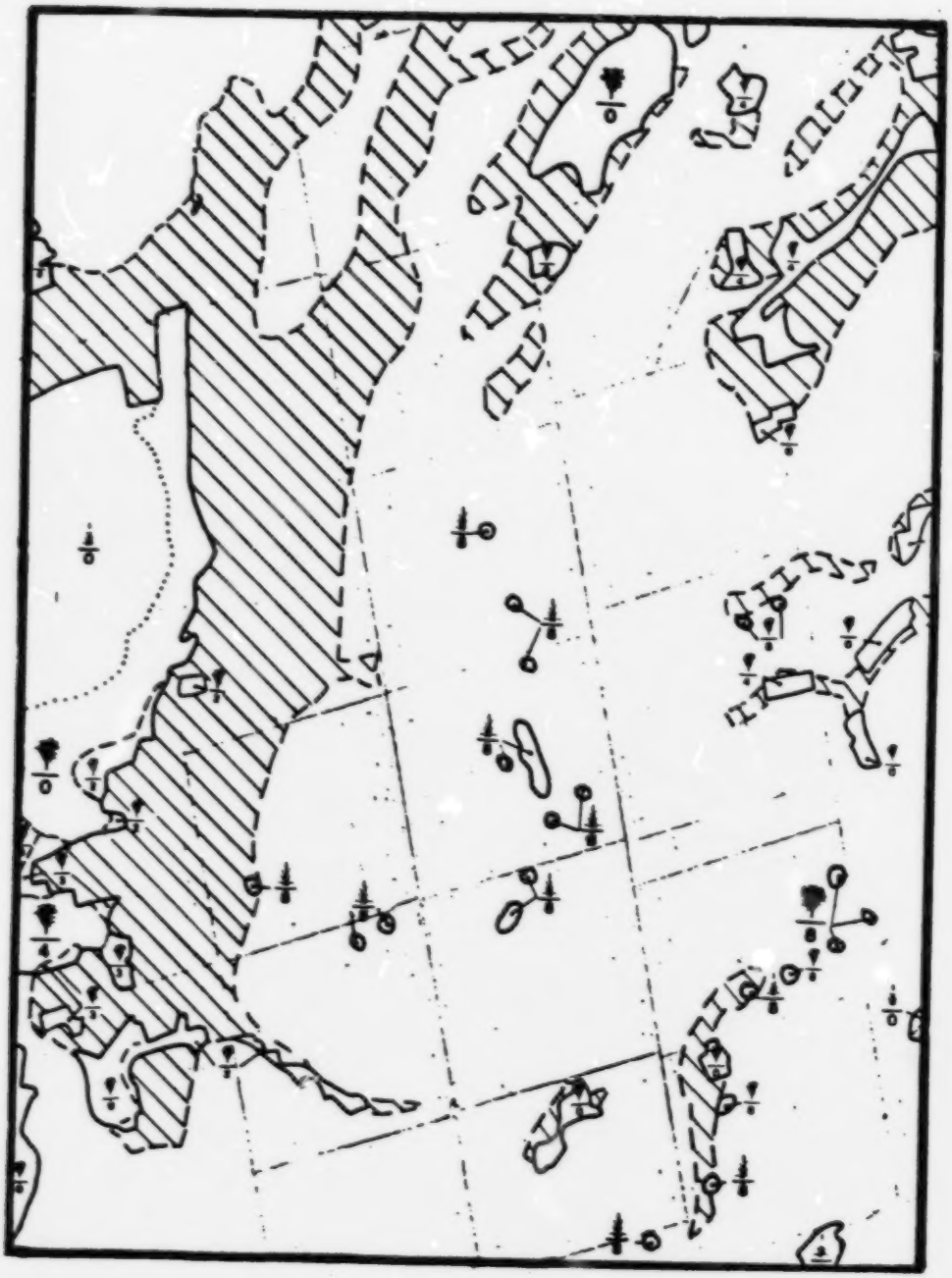
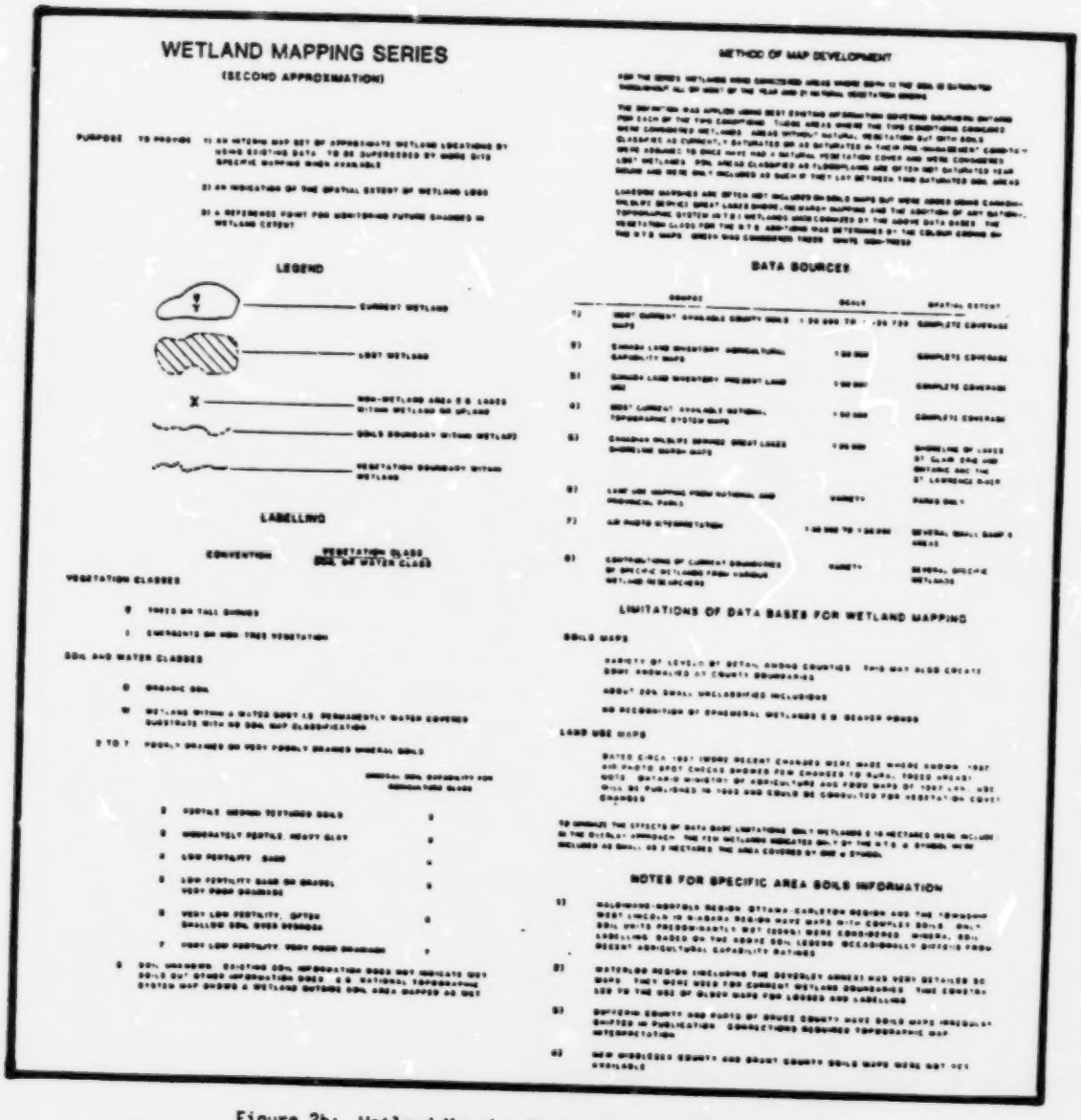


Figure 2a: Excerpt from the Wetland Mapping Approximation Series 310/3 Newmarket



WETLAND MAPPING SERIES

(SECOND APPROXIMATION)

METHOD OF MAP DEVELOPMENT

LEGEND

CURRENT WETLAND

LOST WETLAND

NON-WETLAND AREA E.G. LAKES WITHIN WETLAND OR UPLAND

SOILS BOUNDARY WITHIN WETLAND

VEGETATION BOUNDARY WITHIN WETLAND

DATA SOURCES

LABELLING

CONVENTION

VEGETATION CLASSES

SOIL AND WATER CLASSES

LIMITATIONS OF DATA BASES FOR WETLAND MAPPING

SOILS MAPS

LAND USE MAPS

NOTES FOR SPECIFIC AREA SOILS INFORMATION

Figure 2b: Wetland Mapping Series (Second Approximation) Legend (Environment Canada, 1983)

3.0 APPLICATION OF THE SNELL METHODOLOGY OUTSIDE OF SOUTHERN ONTARIO

3.1 A REVIEW OF THE CANADA LAND INVENTORY (CLI)

Prior to applying Snell's overlay technique, it is first necessary to review the objectives, and limitations of CLI for the other provinces in order to obtain an understanding of the data base. CLI is a federal-provincial mapping program initiated in 1963 to provide a comprehensive survey of land capabilities across southern Canada. Lands were classified, at the reconnaissance level according to: (1) their physical capability for use in agriculture, forestry, recreation and wildlife, and (2) their 1965-68 land use. The resulting data was intended for use at the regional planning level (Environment Canada, 1978).

CLI data are provided at various scales:

1) manuscript maps at 1:50 000;
2) published maps at 1:250 000 (or 1:125 000 in British Columbia);and
3) published maps at 1:1 000 000.

(Coombs and Thie, 1979)

Data are also available, generally at 1:250 000 scale, on the Canada Land Data System (CLDS) in Ottawa at Environment Canada (Coombs and Thie, 1979).

As previously mentioned, the 1:50 000 CLI soil capability for agriculture and 1965-68 land use maps are required for the Snell methodology. The compilation techniques used for these two map series are presented in Appendices I and II.

An important factor to consider when using CLI maps is the consistency of the mapped units across the country (Rees, 1977). Each classification designed for the inventory was selected to achieve a common objective, but its application has varied from province to province due to different analysts and the biophysical variability that exists between regions (Rees, 1977). CLI data must therefore be interpreted within the context of each province.

3.1.1 PROVINCIAL REVIEW OF CLI SOIL CAPABILITY FOR AGRICULTURE MAPS

After reviewing selected soil capability maps in all the provinces, it was found that British Columbia, Alberta, Saskatchewan, Manitoba, Quebec, and New Brunswick made extensive use of complex soil capability codes, unlike the predominantly simple codes used in southern Ontario. Complex capability codes are used when more than one soil capability exists within a polygon. The distribution of the different capabilities is such that it is not possible to separate them at the 1:50 000 mapping scale.

Complex codes generally consist of two soil capabilities and their limitations, such as $4^{6}_{P}5^{4}_{W}$: sixty percent of the polygon consists of class 4 land limited by (P) stones, and forty percent is class 5 land limited by (W) wetness. In the case of British Columbia, often three capability codes were combined in one polygon.

The use of complexed capability codes would often make it difficult to determine wetlands using the Snell methodology. This is because it is not possible to determine the geographic location of the wet soil or

organic component of the code. Although not all of the capability codes of each of the provinces are complexed, the results of determining wetlands using only those single code units, would on visual evaluation, generally not provide an accurate inventory of wet soils for an area. However, statistical evaluations without precise geographic location plotting, would be possible using computerized techniques.

Nova Scotia, Prince Edward Island and southern Ontario are the only areas where extensive use of simple capability codes was undertaken. In northern Ontario, there is an increased use of complexed soil capability codes, limiting the use of the Snell methodology. Other limitations noted are related to scale and are summarized below. Soil capability maps for Newfoundland are not available at 1:50 000.

Soil capability mapping in Alberta and Saskatchewan has been on base maps other than NTS 1:50 000 map sheets, making it difficult to produce overlays with the 1965-68 land use maps. In Alberta, soil capability was mapped at either 1:50 000 or 1:63 360, depending on the availability of base maps at the time of mapping. Saskatchewan soil capability was mapped according to rural municipalities at 1:50 000, requiring the compilation of numerous rural municipalities to make up one NTS map sheet. For the remainder of the provinces, all soil capability manuscript maps are at 1:50 000.

The extensive use of complexed soil capability codes is the primary factor limiting the usefulness of CLI as a suitable, single data base for the mapping of wet and organic soils.

3.1.2 PROVINCIAL REVIEW OF CLI 1965-68 LAND USE MAPS

The program to map 1965-68 land use for CLI was coordinated by the Geographical Branch of the Canadian Department of Energy, Mines and Resources. These maps have not been published, but exist as 1:50 000 manuscript maps and a limited amount of computer mapping inputs, at 1:50 000 and 1:250 000 (Environment Canada, 1978). Mapping of land use by this central agency reduced the possibility of different interpretations of land use categories. Only minor discrepancies are likely to exist with regard to this land use mapping program across Canada.

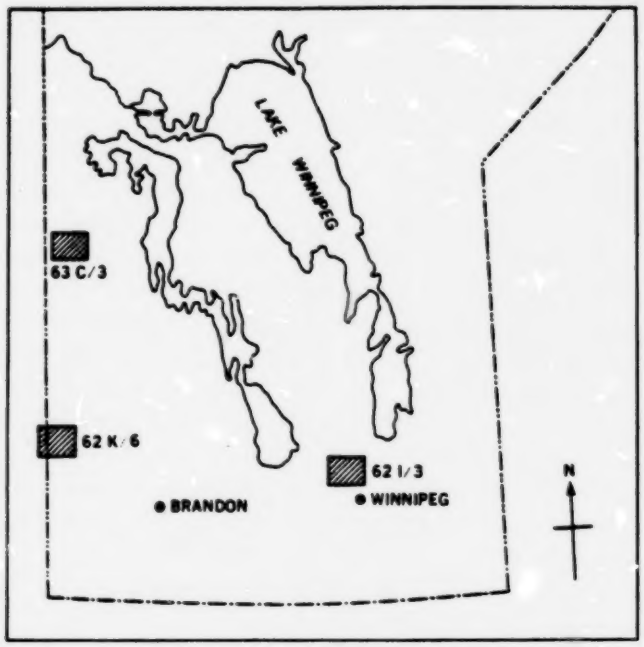
3.2 SELECTION OF THE TEST AREAS

Selection of the test areas was made on the basis of two criteria: (1) the availability of CLI manuscript maps at the uniform scale of 1:50 000 (due to time constraints), and (2) the need to compare the application of the Snell methodology in an area of complexed codes to an area of simple codes.

The test areas selected were three NTS map sheets in Manitoba: 62I/3, 62K/6 and 62C/3 and two in Nova Scotia: 21A/14 and 11D/14. A brief review of the physical environment of each map sheet is presented in Appendix III. The following sections will demonstrate the applicability of the Snell methodology for each test area.

3.2.1 APPLICATION OF THE SNELL METHODOLOGY IN MANITOBA

The three Manitoba test areas, (Map 1), 62I/3, Stonewall, 62K/6 Birtle, and 63C/3 Swan River are found within the "prairie



Map 1. Location of the Study Areas in Southern Manitoba

pothole region", an area that closely coincides with the prairie grassland and aspen parkland regions of western Canada (Lynch-Stewart, 1983). The region is characterized by numerous semi-permanent ponds and marshes called "sloughs" or "potholes", which usually support an encircling tree or shrub border (Zoltai, 1979). The wetlands are associated with gleysolic soils and shallow open water. Shallow open water is considered to be water less than 2 metres deep (Tarnocai, 1979). Based on the association with prairie wetlands and the underlying soil, it is possible to apply the wetland definition and assumptions, used by Snell, to this region.

The mapping of prairie wetlands, specifically the potholes, has presented a formidable challenge. Prairie potholes are distinct from other wetlands in Canada due to their seasonal nature, density and small size.

The surplus ground water available to wetlands is largely dependent on the amount of water available during snow melt. On average, 33 percent of wetlands identified as containing water in May are dry by August (Jahn, 1979). Summer precipitation, generally in the form of local showers, only adds a significant amount of water to an area of potholes at certain times (Gollup, 1965). The result is a general increase in the number of potholes during the spring and following a summer rain. The mapping of existing potholes can therefore be greatly influenced by the time of year when the air photographs are taken and when field work is conducted.

The density of wetlands on the prairies must also be considered when mapping. Wetland

inventories have arrived at estimates ranging from an average of 73 wetlands per square kilometre (Gollup, 1965) for the whole of the prairie region to a maximum density of 310 wetlands per square kilometre for southern Saskatchewan (Lynch et al, 1963).

When density is combined with size, 82 to 87 percent of prairie wetlands are less than 0.25 hectares in size (Millar, 1979). This has meant that the majority of the wetlands are below the minimum mappable size at a 1:50 000 scale. Any attempts to map wetlands at that scale would only result in a mapping of approximately 18 percent of the wetlands, a figure that would have to be evaluated with regard to its reflection of the true situation.

The three above-mentioned elements of density, size and seasonal nature of wetlands in the prairies affect the suitability of CLI as an appropriate data base for detecting existing and lost wetlands.

A comparison of CLI soil capability maps and Manitoba Soil Survey maps at 1:126 720 for the Stonewall and Birtle map sheets indicated that the soil survey units were directly transferred to the 1:50 000 base maps. Soil unit descriptions were then reinterpreted on the basis of CLI soil capability criteria and a capability rating assigned.

The natural variation of soils over units as large as those mapped at 1:126 720, has meant that more than one soil type exists within a soil unit and therefore more than one soil capability is assigned to a unit. At the original scale, it was possible to delineate only the largest wetlands, and although the map scale was increased to 1:50 000, wet soils and organic areas now mappable were not added to the map. As a result, a large percentage of prairie wetlands have not been indicated using CLI, but have been included as part of the complex capability codes assigned to the polygons. As previously discussed, it is not possible to determine the exact spatial location of wet soils from complexed codes.

Complexing is particularly prevalent on the 62K/6 Birtle map sheet. Capability ratings are often at opposite ends of the scale, for example $3^{8}_{M}6^{2}_{W}$. The capability rating of 80 percent class 3 with a low moisture (M) holding capacity refers to the knolls or hills in the polygon where drought conditions exist; the rating of 6 with excess water (W) records the presence of the scattered wet soils over 20 percent of the polygon. The exact locations of these scattered wet soils is required for the Snell approach, but cannot be determined without detailed air photograph and field work.

The 62I/3, Stonewall, map sheet also has a high number of complex units, many are complexed according to soil capability with the same wetness limitation on each rating, for example $2^{8}_{W}3^{2}_{W}$. Thus, using Snell's definition, many of the polygons could be considered wet soils. This aspect of prairie wetland mapping will be discussed further under Section 3.2.3 below.

The Swan River map sheet (63C/3) contains very few complexed units, but many of the units cannot be used to delineate wet soils. This is because many of the wet soil units indicated on the NTS map were bisected with unit lines and the "X" limitation was often used to describe any limitations to

agriculture. ("X" is used to denote more than two limitations). It could therefore not be determined if wet soils were present within the unit.

Application of CLI present land use mapping to determine land use change on these wet soils was found to be inadequate for detecting land use change on all three map sheets. On those units where soil capability had been complexed, it was not possible to determine which class of a capability rating corresponded to a particular land use.

The CLI land use maps were found to lack sufficient detail to determine where land use changes had occurred in relation to wetlands. Studies by Millar (1969; 1976) and Goodman and Pryor (1972) on land use change on prairie wetlands have found that cultivation commonly does not occur up to the waters edge of the wetland. A narrow ring of natural vegetation is often left. Should this be the case, a wetland would be in a relatively natural condition. It is, however, not possible to make this determination from the CLI 1965-68 land use data.

In cases where wet soils have been delineated on the agriculture capability maps and overlain by 1965-68 land use, agriculture and pasture appear to extend up to the edge of the wetlands. The detail of the land use maps is insufficient to detect if vegetated borders have been left around the wetlands.

The inadequacies of CLI mapping for determining wetlands and land use change over the three test areas were found to extend over the whole of the prairie grassland - aspen parkland region. While the basic wetland definition and assumptions used by Snell are applicable in the prairies, it is, however, not possible to use the CLI data base to detect wetlands. A more detailed map series of wet and organic soils and land use is required.

3.2.2 SUMMARY AND CONCLUSIONS

The wetland definition and assumptions used by Snell are applicable in the prairie situation examined. CLI, however, does not provide an adequate data base from which to determine wetlands and land use change. This is due to:

1) inadequate scale to detect any but the largest wetlands; 82 to 87 percent of the wetlands would remain unmapped.

2) Complexed agriculture capability codes indicate the occurrence of wet soils, but do not permit them to be mapped.

3) 1965-68 land use cannot be applied to complexed agricultural capability units to obtain an evaluation of the status of wetlands.

It would only be possible to conduct a wetland inventory of the prairies using the basic assumptions of the Snell approach if another more detailed data base indicating wet soils, organics and land use were available.

3.2.3 CONSIDERATIONS

A related means of obtaining a broad perspective of prairie wetlands does exist using CLI. Zoltai (pers. comm.) and Tarnocai

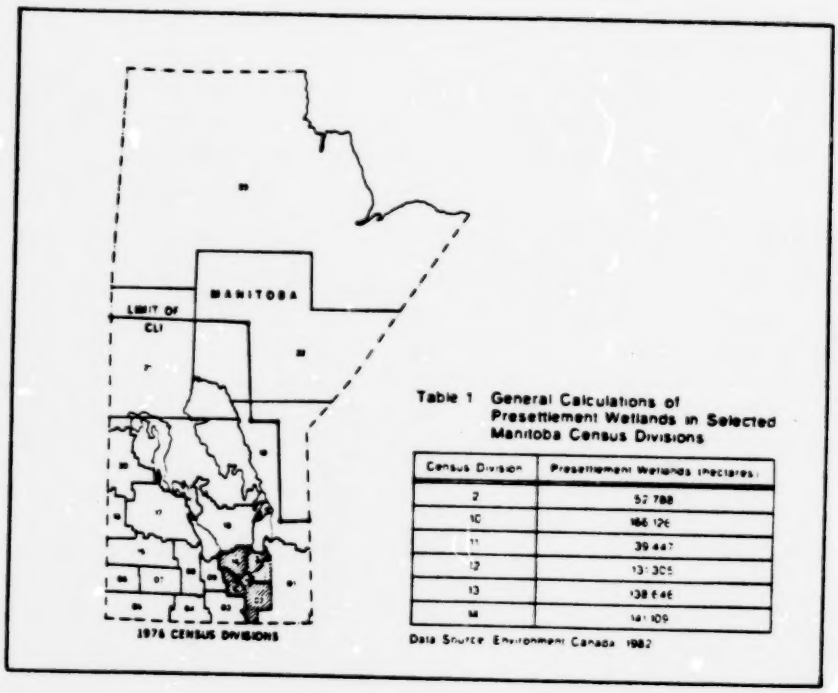


Table 1 General Calculations of Presettlement Wetlands in Selected Manitoba Census Divisions

Census Division	Presettlement Wetlands (hectares)
7	52 788
10	166 126
11	39 447
12	131 305
13	138 646
14	141 109

Data Source: Environment Canada 1982

(pers. comm.), supported by historical evidence and soils data, concur that the Lake Agassiz and Regina Plain, prior to settlement, were extensive wetlands. The installation of drainage ditches and tiles since the arrival of the early settlers has improved the soil's agriculture capability from its natural state limited by wetness. The CLI soil capability rating could reflect the soil conditions prior to settlement. Applying this hypothesis, it is then possible to arrive at a general area of wetlands that once existed in central Manitoba and Saskatchewan (Table 1).

CLDS has been used to "decomplex" the soil capability codes of the CLI 1:250 000 maps by census division for all provinces. Decomplexing involves utilization of the dominantly coded portion of the data in each unit, but does not create "new" or "more correct" data. In fact, it reduces the general "accuracy" of the data itself. If a physiographic map of southern Manitoba is compared to the generalized CLI soil capability map, it is possible to determine the extent of glacial Lake Agassiz and arrive at a general area of soils limited by wetness. It is important to note that not all of the wet soils in the Lake Agassiz plain have been converted to alternate land uses. Using the 1:250 000 maps, it is possible to theoretically locate present day wetlands by delineating soil capability polygons rated as class 6 and 7 limited by wetness and organic areas (Zoltai, pers. comm.).

It must be remembered that in the context of the size and density of prairie wetlands all but the largest wetlands will not be mapped using this technique. The use of this

generalized CLI information is somewhat similar to the Snell methodology but in a more simplified fashion. It also uses a somewhat tenuous assumption that poor agriculture capability (wet soil) units have remained in a natural state and not been used for other purposes.

In another study conducted by Goodman and Pryor (1972), statistically, it was found that significantly higher rates of wetland loss occurred on CLI agricultural classes 1 to 4 lands, than on poorer classes 5 to 7 lands. It was speculated that the CLI soil capability maps may represent a mapping of potential threat of wet soil loss. Using this theory, it would then be possible to delineate those areas where wetland conversion studies should focus.

The two considerations presented are possible means of using CLI for obtaining limited data with regard to wetlands. They, however, do not address the original question of the location of the existing wetlands for the purpose of land use change monitoring.

3.3 APPLICATION OF THE SNELL METHODOLOGY IN NOVA SCOTIA

The Snell methodology was tested in two different regions in Nova Scotia. The first was Bridgewater, NTS 21A/14 located in the Annapolis Valley; the second, Musquodoboit, NTS 11D/14, east of Halifax (Map 2).

Wetlands of Nova Scotia are characterized by domed and raised bogs, fens and tidal and freshwater marshes (Zoltai, 1979). Wetlands are associated with gleysolic and organic soils (Tarnocai, 1979). It is therefore possible to apply Snell's wetland definition and assumptions to this area.

3.3.1 EVALUATION OF THE CLI MAPPING

As previously mentioned, CLI soil capability maps for Nova Scotia were found to consist of single capability coded polygons. It was possible to correlate 1:63 360 provincial soils maps with the capability maps and thereby correlate soil capability ratings and wetness limitations to actual soil units. As is the case in southern Ontario, poorly and very poorly drained soils correlated with those soils limited by wetness and peaty soils, correlate closely with organic soils.

CLI 1965-68 land use maps are available at 1:50 000 and were used to provide land use data for the Musquodoboit map sheet. More recent land use data available through the Lands Directorate's Prime Resource Lands (PRL) program, and the prime agricultural land inventory, 1976, for the Annapolis Valley was used for the Bridgewater map sheet.

3.3.2 DETECTION OF WETLANDS ON THE TWO TEST AREAS

Using the same overlay technique as the Ontario Snell approach, it was possible to delineate existing and lost wetlands on both map sheets. In order to verify the results of the methodology a comparison was made with a wetlands mapping program presently underway in the Atlantic provinces.

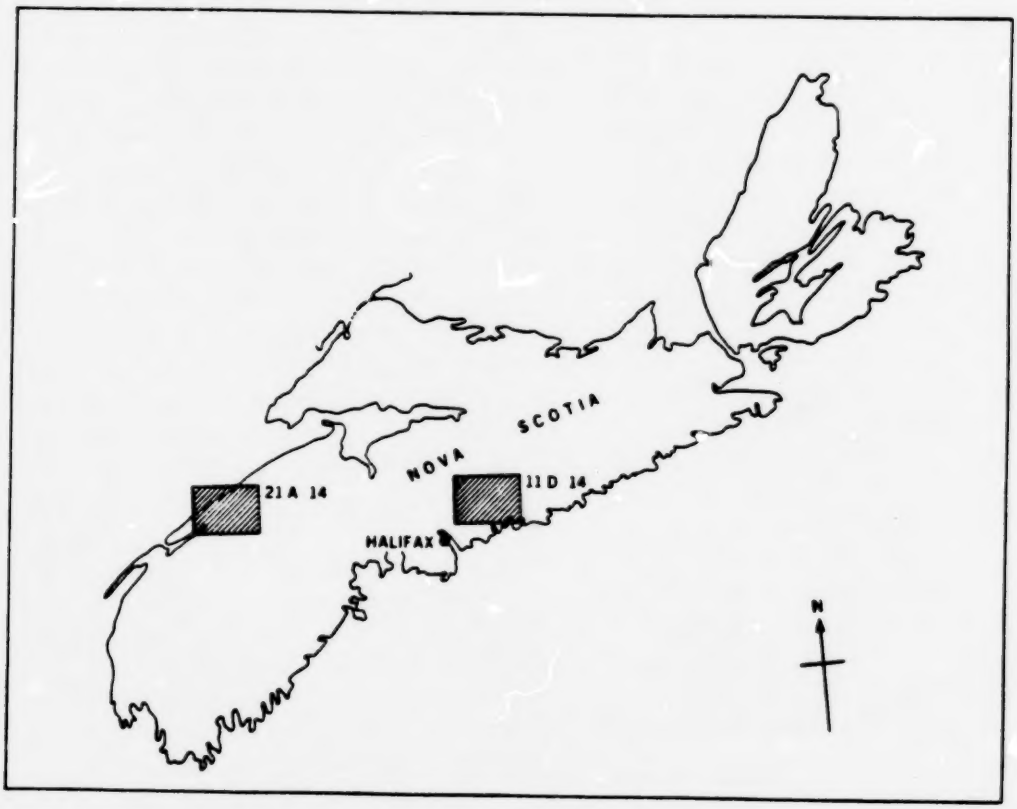
The Wetland Protection Mapping and Designation Program, (WPMDP), is a joint provincial-federal project involving Nova Scotia, Prince Edward Island, New Brunswick

and the Canadian Wildlife Service (CWS). The objective is to:

> "provide information on the classification, size, distribution and wildlife value in the Maritimes"
> (Smith et al, 1981)

Once completed, the program will be an inventory of most freshwater and coastal wetlands greater than 0.25 hectares in size. To-date, the provinces of Nova Scotia and Prince Edward Island have been completed. It is anticipated that New Brunswick will be mapped by 1986 (Smith et al, 1981).

It should be noted that the criteria used for identifying and delineating wetlands in the WPMDP is different than that used by Snell. Wetlands are identified by a classification system designed by F.C. Golet (1972) for freshwater environments and by L.M. Cowardin (1979) for coastal wetlands. Its stress on wildlife, selects mainly hydrological values



Map 2. Study Area Locations Within Nova Scotia

for mapping. Not all wetlands are mapped; in particular, inland and forested swamps are omitted whereas the Snell approach includes the wetlands as well as other NTS wetland symbolized sites. Forest swamps have significantly important value for wildlife and hydrology. Their lack of inclusion in the WPMDP is a serious omission. The mapping program is based on detailed interpretation of recent, available aerial photography and field checking. In addition the minimum map units are different, being 0.25 ha for the WAMDP, and 10 ha with the Snell method. A. Smith (pers. comm.) indicated that five to eight percent of the wetlands in Nova Scotia had been field checked.

A comparison of the two wetland mapping techniques found that very few of the wetlands delineated by the WPMDP were included within the wetlands determined using the Snell technique. This was particularly evident on the Musquodoboit map sheet. A discrepancy between the results of the two mapping programs was resolved through a check of the wetland units on available aerial photography. It was found that, in almost all cases, the variation in unit boundaries could be attributed to the inclusion of forested swamp areas on wet mineral soil as wetlands using the Snell method. This class is not present in the WPMDP.

The use of large scale aerial photography has enabled the WPMDP to delineate many more small wetlands than are detected using the Snell method. This was evident along the coastal areas and in the remote areas of both map sheets.

3.3.3 RESULTS

Using the Snell methodology, it is possible to delineate 3 637.1 hectares of the 1965-68 existing wetland on the Bridgewater map sheet. The WPMDP delineates an additional 1 124.4 hectares, 69 percent less wetland than the Snell method. The differences between the two studies can largely be accounted for by the inclusion of forest swamps as wetlands with the Snell approach.

It is possible using the Snell approach to determine 3 406.3 hectares of "lost" wetland on the Bridgewater sheet, with the majority of wetlands being converted to agriculture either by draining or, in the case of coastal marshes, by dyking since settlement. Summation of the wetlands determined by Snell and the additional wetlands delineated by WPMDP indicates that there were 8 167.8 hectares of wetland on the Bridgewater sheet prior to settlement. Since that time 42 percent has been lost. This assumes virtually no overlap between the mapped results of these two approaches which leads to an overestimate of the original presettlement wetland area. No evaluation in this study was undertaken to identify the level of this overlap due to time constraints.

Analysis of the Musquodoboit map sheet produces different results. The WPMDP determined that there are 3 829.2 hectares of wetland on the map sheet; using Snell it was found that there were 2 144.3 hectares. The difference between the two methods is the result of a combination of two factors: (1) numerous small wetlands in the remote areas were not detected using the Snell approach due to limiting scale differences

Table 2. Results of the Snell Methodology and Wetland Protection Mapping and Designation Program (WPMDP)

Test Area 21A/14 - Bridgewater

	Hectares of Wetland	Percentage of Presettlement Wetlands
Current Wetland (WPMDP)	1124.4	13.8
Current Wetland (Snell)	3637.1	44.5
Lost Wetland (Snell)	3406.3	41.7
Presettlement Wetland (Snell & WPMDP)	8167.8	100.0

Test Area 11D/14 - Musquodoboit

	Hectares of Wetland	Percentage of Presettlement Wetlands
Current Wetland (WPMDP)	3829.2	56.3
Current Wetland (Snell)	2144.3	31.6
Lost Wetland (Snell)	821.9	12.1
Presettlement Wetland (Snell & WPMDP)	6795.4	100.0

in the CLI data, and (2) the inclusion of forest swamps using the Snell method increased the wetland area in the Musquodoboit Valley. In this case WPMDP detected 45 percent more wetland.

Using the Snell appproach, 821.9 hectares were determined as being lost wetlands. In summary, there are (as of 1968-80) 5 973.5 hectares of wetland on the Musquodoboit map sheet, (Snell plus WPMDP values), while prior to settlement there were 6 795.4 hectares, a loss of 12 percent (Table 2).

3.3.4 SUMMARY AND CONCLUSIONS

It is possible to apply the Snell methodology successfully in Nova Scotia. The availability of a much more detailed wetland mapping program for the province should be utilized in addition, as it delineates many small wetlands not identified using Snell. In turn, the Snell approach identifies wetland types not included in the WPMDP. In particular, this includes forested swamps. The combination of the two mapping programs would provide an accurate, detailed inventory of wetlands for Nova Scotia on which land use change studies could be based.

Having delineated wet soil and organic units, it is then possible to determine land use change by overlaying CLI 1965-68 or any other more recent maps should they become available. Ongoing land use studies are necessary to maintain an understanding of how the wetland situation is changing in the Atlantic Region.

4.0 RECOMMENDATIONS

1) The numerous quantitative studies conducted on the impact of land use change on wetlands for the prairies, as summarized by Lynch-Stewart, 1983 (Appendix IV), provide the rudiments of a land use change monitoring program. A collection of the maps and data produced for each of the studies, when compiled would provide the preliminary frame work from which one could coordinate and monitor future land use change studies.

2) Should any new mapping of wetlands and land use change be undertaken in the prairie pothole region, it would be recommended that it be done using aerial photography and field checking, as no suitable data base exists as yet that is adequate to delineate a large percentage of the prairie wetlands, wet soils or vegetative cover.

3) The possibility of interpreting high resolution satellite imagery for mapping wetlands and land use change in all parts of Canada should be further examined. This may provide an alternative to the conventional methodologies of air photo interpretation and field checking.

4) An inventory of provincial and federal wetland mapping programs is recommended. Provincial interests in peatlands have led to extensive mapping programs in Ontario, Newfoundland, New Brunswick and Manitoba. These inventories could provide some of the base data required for a national wetland inventory and for detecting land use change on wetlands.

5) It is recommended that a provincially-based wetland map series be compiled for Nova Scotia, Prince Edward Island and New Brunswick using both the Snell approach and the Wetlands Protection Mapping and Designation Program. Contact should be made with CWS to discuss any land use change monitoring on wetlands they plan to undertake using the WPMDP. A more complete picture of wetland land use conversions in the Atlantic Region would be created by use of these two complementary approaches, rather than by either alone.

5.0 A COMPARISON OF COMPUTER DATA AND THE 1981 MANUAL APPROACH FOR DETERMINING LAND USE CHANGE ON WETLANDS IN URBAN CENTRED REGIONS

5.1 A REVIEW OF URBAN CENTRED REGIONS

The Urban Centred Region (UCR) component of the Canada Land Use Monitoring Progam (CLUMP) is intended to produce a comprehensive review of land use changes in urban areas across Canada. UCR's are defined as urban centers with populations greater than 25 000. Boundaries are based on Census Metropolitan Areas and Census Agglomerations as defined by Statistics Canada (Warren and Rump, 1981). At present there are 74 UCR's in Canada: 19 in the western provinces, 29 in Ontario, 19 in Quebec, and 7 in the Atlantic provinces.

Data sources for the studies are CLI manuscript maps for agriculture, forestry, recreation, wildlife, waterfowl and land use. Land use for each UCR has been updated, usually every five years, coincident with the national census. Selected data sources have been digitized and entered into the Canada Land Data System (CLDS) and can be retrieved in both tabular and graphic form.

Wetlands near Canadian cities are believed to be undergoing significant coversion but little is well documented. It was felt that a comparison of wetland land use conversion using CLDS-UCR data by computerized analysis and by the manual analysis of Snell (1981) would be useful to develop a better understanding. Both approaches essentially use the Snell methodology although the CLDS-UCR has more recent land use coverage (i.e. 1977 versus the 1965-68 period used in Snell's Second Approximation). In addition, Snell's manual approach is slightly different, since it incorporated small NTS symbols and permitted adjustment of map registration errors directly. Both the CLDS and Second Approximation data bases, however, may suffer equally from unknown levels of error associated with input and useage of original agricultural land capability maps produced on 1:50 000 scale, non-stable bases.

The Oshawa UCR, (Map 3), was selected for this comparison study due to the extensive loss of wetlands in the region since settlement and increasing pressures for land use change on Second Marsh, one of the few remaining shoreline marshes along Lake Ontario. Having identified the Oshawa UCR on the corresponding Wetland Second Approximation Map, 31M/15, (Environment Canada, 1983), it is possible to conduct a comparative study of their effectiveness in determining land use change on wetlands.

5.2 LAND USE CHANGE ON WETLANDS - OSHAWA UCR

It is possible, using the CLDS-UCR computer data base, to derive a breakdown of 1968, 1971 and 1977 land use on both agricultural land limited by wetness and organic soils, and thereby determine lost and existing wetlands at the time of each land use study. Three data selections were made using the Oshawa UCR data base, resulting in a series of three composite maps and tables (Maps 4a,b,c):

- 4a) Presettlement Wetlands-Oshawa UCR
- 4b) Land Use Change on Wetlands Oshawa UCR, Settlement to 1977
- 4c) Wetlands which have Reverted from

Alternate Land Uses to Natural Wetland Vegetation, 1968-1977

Wetlands, theoretically, made up 9.3%, (Table 5a), of the Oshawa UCR prior to settlement. By 1968 466 hectares remained, a loss of 74.1%. There has been a slight net gain of 116 hectares or 6.0% of natural vegetation on wetlands between 1968 and 1977 (Table 5b). Of these 116 hectares which were allowed to revert to natural vegetation, 44 hectares were cropland, 11 hectares in horticulture, 41 hectares of unimproved pasture, 17 hectares in extraction and 3 hectares of recreational land in 1968 (Table 5c).

Since 1968 the rate of land use conversion of natural wetlands appears to have stabilized. The percentage of converted land between 1968 and 1977 has remained relatively constant. As noted above, by 1968 74.1% of the presettlement wetlands in the Oshawa UCR had been converted to other land uses; in 1971 this figure declined to 72.8% and in 1977 it had declined only slightly to 72.6%, indicating a stable situation.

TABLE 5a Presettlement Wetlands - Oshawa UCR

Presettlement Wetlands		
Wetland Type	Hectares	% of Oshawa UCR
Organic	251	1.3
Wet Soil	1 548	8.0
Total	1 799	9.3

*All figures have been rounded off to the nearest hectare.

Map 3. The Approximate Location of the Oshawa Urban Centred Region, Southern Ontario

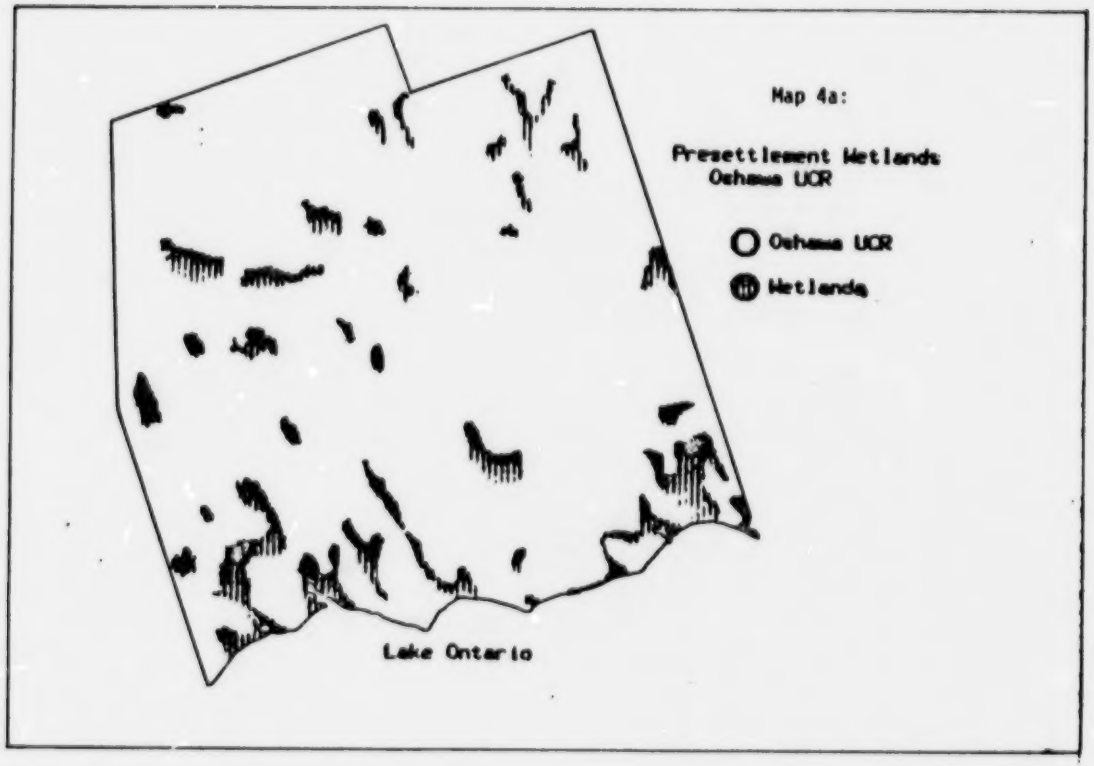
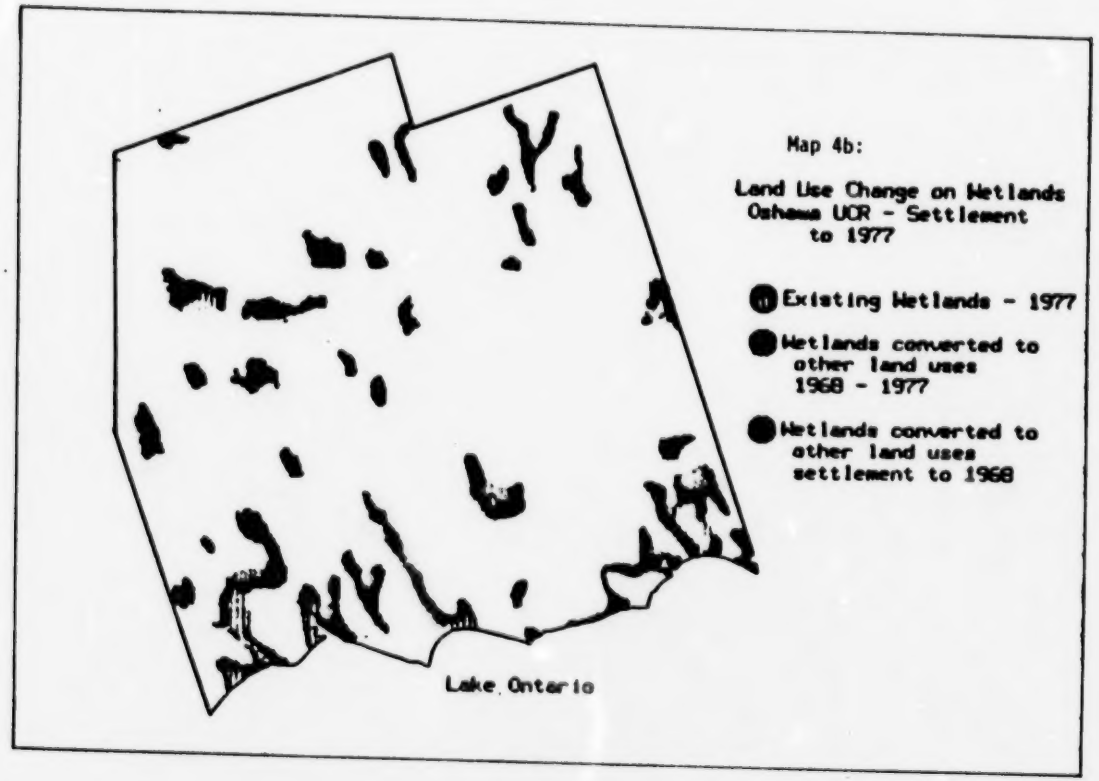

Map 4a:
Presettlement Wetlands
Oshawa UCR
Oshawa UCR
Wetlands
Lake Ontario

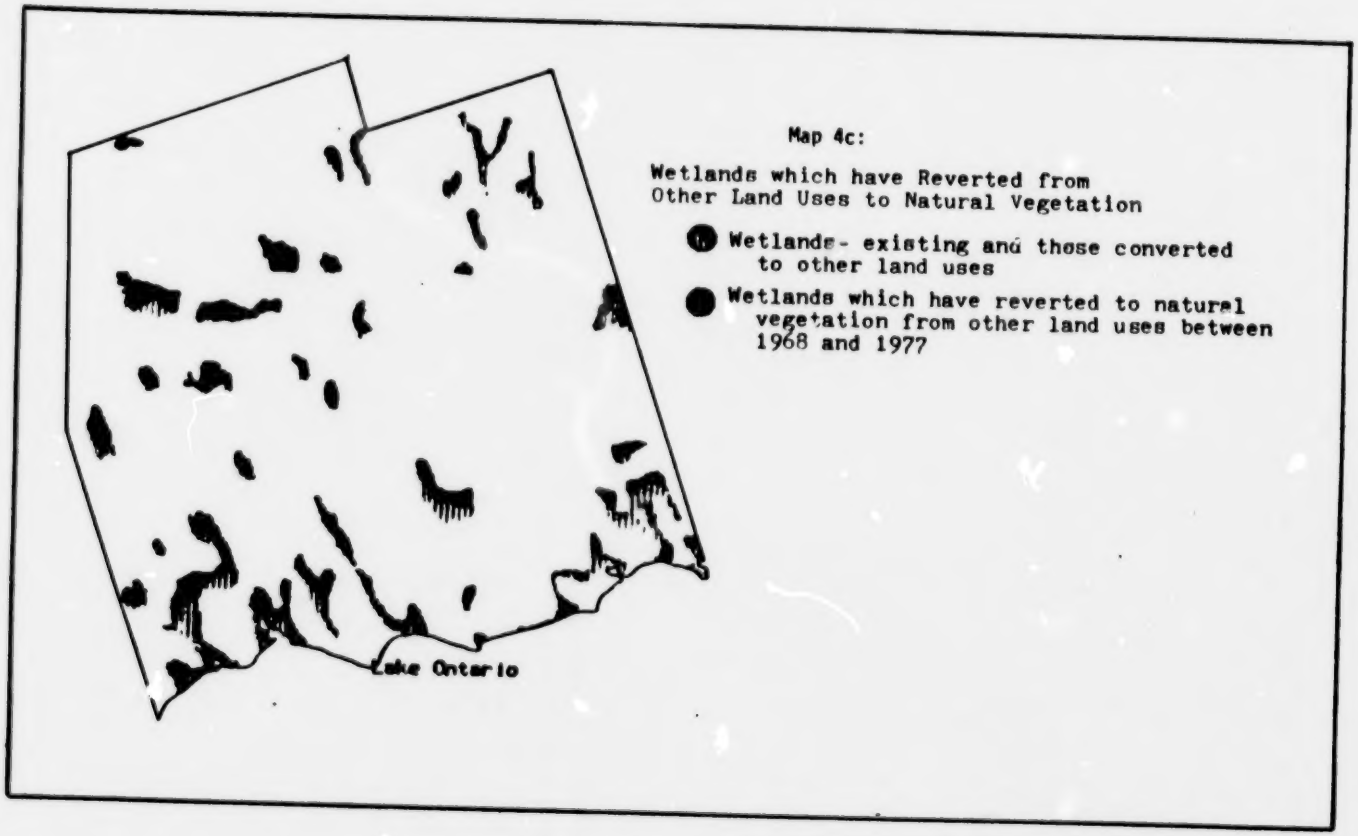
Table 5b: Land Use Change on Wetlands - Presettlement to 1977

Canada Land Inventory Land Use on Wetlands	1968		1971		1977	
	Area (ha)*	% Total wetlands	Area (ha)*	% Total wetlands	Area (ha)*	% Total wetlands
Natural wetland						
Woodland:						
(T) Productive Woodland	177	9.8	218	12.1	200	11.1
(U) Unproductive Woodland	102	5.7	113	16.3	61	3.4
Swamp/Marsh (M)	187	10.4	158	8.8	233	13.0
Total	466	25.9	489	27.2	494	27.5
Converted Wetland						
Agriculture:						
(A) Cropland	582	32.4	598	33.2	542	30.1
(H) Horticulture	50	2.8	22	1.2	7	0.4
(G) Orchards/Vineyards	17	0.9	19	1.1	29	1.6
(P) Improved Pasture	--	--	--	--	--	--
(K) Unimproved Pasture	366	20.3	208	11.6	108	6.0
Extraction (E)	18	1.0	37	2.1	12	0.7
Recreation (O)	11	0.6	18	1.0	27	1.5
Urban (U)	289	16.1	407	22.6	581	32.3
Total	1333	74.1	1309	72.8	1306	72.6

Rate of Conversion: Settlement to 1968 (net loss) -74.1% 1968 to 1971 (net gain) +4.8% 1971 to 1977 (net gain) +1.0%

*All figures have been rounded off to the nearest hectare.


Map 4b:
Land Use Change on Wetlands
Oshawa UCR - Settlement
to 1977
Existing Wetlands - 1977
Wetlands converted to
other land uses
1968 - 1977
Wetlands converted to
other land uses
settlement to 1968
Lake Ontario



Map 4c:

Wetlands which have Reverted from
Other Land Uses to Natural Vegetation

- Wetlands- existing and those converted to other land uses
- Wetlands which have reverted to natural vegetation from other land uses between 1968 and 1977

Table 5c: Wetlands which have Reverted from Alternate Land Uses to Natural Vegetation 1968 - 1977

Land Use	1968		1971		1977	
	Area (ha)	% of Total Reverted wetland	Area (ha)	% of Total Reverted wetland	Area (ha)	% of Total Reverted wetland
Agriculture:						
Cropland	44	37.9	28	24.1	--	--
Horticulture	11	9.5	5	4.3	--	--
Unimproved Pasture	41	35.3	7	6.0	--	--
Extraction	17	14.7	26	22.4	--	--
Recreation	3	2.6	--	--	--	--
Woodland						
Productive Woodland	--	--	24	20.8	68	58.5
Unproductive Woodland	--	--	26	22.4	19	16.4
Swamp/Marsh	--	--	--	--	29	25.0
Total	116	100	116	100	116	100

The dominant land use on wetlands for Oshawa is urban. In 1977 urban land use accounted for 32.3% of the original presettlement wetland area. Other major uses were cropland 30.1% and natural vegetation 27.5%. The largest net conversion of wetlands was due to urban land use. Between 1968 and 1977, 292 hectares were built up, a net gain of 50.2% of urban land at the expense of wetland. All other land uses, with the exception of natural vegetation, during the 19 year study period experienced a decline in area on wetlands. This may be due to conversion of these land uses to urban uses, largely as a result of population pressures.

5.3 A COMPARISON BETWEEN LAND USE CHANGE ON WETLANDS AS DETERMINED BY THE SNELL APPROACH MANUALLY AND BY CLDS ANALYSIS FOR OSHAWA

Prior to comparing the two wetland maps for Oshawa, a brief review is necessary of the data bases used by Snell for the Wetland Mapping Series (Second Approximation). For the map series, CLI soil capability maps and late 1960's CLI land use data was used, as this was the only land use data uniformly available across southern Ontario. It is therefore only possible to directly compare the Snell wetland map with the 1968 land use on wetlands available through CLDS (Map 4b and Table 5b).

A visual comparison of the two maps indicates that they are alike. Both indicate similar existing and lost wetland areas. A quantitative comparison of the maps is, however, more difficult, as the Snell Second Approximation map does not provide specific area calculations for the existing or lost wetlands. Digitization of these maps for the Third Approximation Map Series is to begin in January 1984 (Snell, pers. comm.). A dot grid was used to calculate these areas (Table 6).

The total presettlement wetlands for the two studies were found to be similar. Snell delineated 1 712 hectares of wetland; the UCR 1 799 hectares; a difference of 5%. This difference may be accounted for by original CLDS cartographic error, use of unstable map bases, or inaccuracies in the use of a dot grid for calculating areas (Table 6). The manual approach also incorporates small NTS wetland-symbolled areas; CLDS does not. The minimum polygon size in the CLDS data base is 2.6 ha whereas for the Ontario (Second Approximation) Wetland Map Series, this varies from 2-10 ha depending on data source - a significant difference in data "accuracy."

A closer quantitative comparison of Snell and CLDS becomes more difficult due to the reclassification of vegetation by Snell into tall trees or shrubs and emmergents (Figure 2b), rather than using the land use classes of U, T and M (Table 7).

5.4 SUMMARY

The Wetland Map Series (Second Approximation) produced by Elizabeth Snell provides preliminary soils and vegetation data concerning existing wetlands and an approximation of lost wetlands. No supplementary data is currently provided with regard to these areas; however, it is expected such data will become available with the Third Approximation of this map series, now in production.

The UCR program consists of a large number of data inputs which can be manipulated and analyzed to produce a wide range of statistics and graphics. These can in turn be examined to determine rates of specific land use conversion on both lost and existing wetlands. The use of UCR data therefore provides a much more analytical tool in understanding land use change on wetlands.

TABLE 6
A Comparison of Existing and Lost Wetlands for the Oshawa UCR Using the Canada Land Data System and Snell - 1968

	Wetlands 1968	Wetlands converted to other Land Uses 1968 by	Total Presettlement Wetlands
Canada Land Data System	467 ha	1 332 ha	1 799 ha
Snell	404 ha	1 308 ha	1 712 ha

TABLE 7: A Breakdown of Land Use on Wet and Organic Soils for the Oshawa Urban Centred Region Comparing CLDS Computer Data and the Wetland Map Series (Second Approximation) - Snell (1981)

	Year	Land Use - Wet Mineral Soil (ha)*					Land Use - Organic Soil (ha)*				
		U**	T**	M**	Agri-culture	Urban/ Other	U**	T**	M**	Agri-culture	Urban/ Other
Canada Land Data System (CLDS) UCR Data Base	1968	75	142	149	923	260	28	36	38	92	57
	1971	88	177	120	759	404	25	41	38	89	58
	1977	35	164	195	599	556	26	36	38	87	63
		Mineral Soils					Organic Soils				
		Tall Trees or Shrubs		Emmergents			Tall trees or Shrubs		Emmergents	Wetlands within a Waterbody Emmergents	
Snell (1981) Map Base	1968	153		118			45		21	68	

* areas are rounded up to the nearest hectare.
** U - unproductive woodland
T - productive woodland
M - swamp/marsh

It should be noted that the UCR data base may only be able to be used with limited success to delineate wetlands in regions where complexed soil capabilities exist in CLI. Computer inputs for the complexed capability polygons consist of the first agricultural capability class only. Therefore if soils limited by wetness or organics comprise the remainder of the capability code, their presence would be undetected. It is therefore not possible to accurately delineate all areas of wet soils in complexed units (see section 3.1.1) (pers. comm. D. Gierman). The UCR data base of course is limited only to the immediate vicinity of Canada's major cities and cannot be used for extensive areas as done by Snell (1981) for all of southern Ontario.

5.5 RECOMMENDATIONS

1) The CLDS UCR data base evaluation of land use change on wetlands near Canadian cities should be expanded to include other UCR's. Urban areas are prominent in terms of wetland decline. Since 1950, increasing pressures for the dredging, draining and filling of wetlands for urban developments have severely reduced the wetland base (Lynch-Stewart, 1983). By obtaining a comprehensive review of wetland change in urban areas over time, an understanding of regional variations in conversion pressures and trends would likely be developed.

2) A national overview report of wetland conversions in UCR's should be prepared using CLDS analyses and attractive graphics outputs.

6.0 BIBLIOGRAPHY

Barto, W.P., and C.G. Vogel. 1978. Agro-Manitoba Information Package. Manitoba Department of Mines, Natural Resources and Environment. Winnipeg, Manitoba. 325 p.

Canadian Wildlife Service. 1982. Wetland Protection Mapping and Designation Program. Maps 21 A/14, 11D/14. Environment Canada. Sackville, New Brunswick.

Coombs, D.B. and J. Thie. 1979. The Canada Land Inventory System. Environment Canada, Ottawa. 27 p.

Cowardin L.M. 1979. Classification of Wetlands and Deepwater Habitats of the United States. Washington D.C. U.S. Fish and Wildlife Service. Report No. FWS 10 BS-79/31.

Ehrlich, W.A., E.A. Poyser, L.E. Pratt and J.H. Ellis. 1953. Reconnaissance Soil Survey of Winnipeg and Morris Map Sheet Areas. Manitoba Soil Survey, Soil Report No. 5. Winnipeg, Manitoba. 111 p.

Ehrlich, W.A., L.E. Pratt and E.A. Poyser. 1956. Reconnaissance Soil Survey of Rossburn and Virden Map Sheet Areas. Manitoba Soil Survey. Soil Report No. 6. Winnipeg, Manitoba. 121 p.

Ehrlich, W.A., L.E. Pratt and F.P. Leclaire. 1962. Detailed Reconnaissance Soil Survey of Swan River Map Sheet Area. Manitoba Soil Survey. Soil Report No. 13. Winnipeg, Manitoba. 79 p.

Environment Canada. 1972. Soil Capability Classification for Agriculture. Canada Land Inventory Report No. 2. Ottawa. 16 p.

Environment Canada. 1978 (reprint). CLI Objectives, Scope and Organization. Canada Land Inventory Report No. 1. Ottawa. 61 p.

Environment Canada. 1980. Agriculture Capability by Province-Census Division Breakdown, Manitoba/Saskatchewan/ Alberta. Lands Directorate. Environment Canada. Ottawa.

Environment Canada. 1983. The Wetland Mapping Series. Second Approximation. 124 1:50 000 maps, Southern Ontario. Lands Directorate and Canadian Wildlife Service, Ontario Region.

Gierman, D.M. and J. Lenning. 1980. Rural to Urban Land Conversion. Map Folio No.5. Lands Directorate, Environment Canada, Ottawa. 71 p.

Golet, F.C. 1972. Classification and Evaluation of Freshwater Wetlands as Wildlife Habitat in the Glaciated Northeast. Ph.D. thesis, University of Massachusetts.

Gollup, J.B. 1965. Wetland Inventories in Western Canada. Transactions of the Congress of International Game Biologists, vol. 6:pp. 249-264.

Goodman, A.S. and S.P. Pryor. 1972. A Preliminary Study of the Methods and

Rates of Alteration of Waterfowl Habitat in the Black Soil Zone of Western Canada. Unpublished report prepared for the Canadian Wildlife Service. Edmonton, Alberta. 77 p.

John, L.R. 1969. Summary- The Significance of Small Wetlands. Saskatoon Wetlands Seminar. Canadian Wildlife Service Report Series No. 6. Ottawa. pp. 29-34.

Lynch, J.J, C.D. Evans and V.C. Conover. 1963. Inventory of Waterfowl Environment of Prairie Canada. North American Natural Resources Conference Transactions. Vol. 28. pp. 93-109.

Lynch-Stewart, P. 1983. Land Use Change on Wetlands in Southern Canada: Review and Bibliography. Environment Canada Working Paper No. 26. Lands Directorate. Ottawa. 115 p.

MacDougall, D.B., J.D. Cann and J.D. Hilchey. 1963. Soil Survey of Halifax County, Nova Scotia. Nova Scotia Soil Survey. Truro, Nova Scotia. 54 p.

MacDougall, D.B., J.L. Nowland and J.O. Hilchey. 1969. Soil Survey of Annapolis County, Nova Scotia. Canada Department of Agriculture and Nova Scotia Department of Agriculture and Marketing. Truro, Nova Scotia. 84 p.

McClellan, J.B., L. Jersak and C.L.A. Hutton. 1968. A Guide to the Classification of Land Use for the Canada Land Inventory. Dept. of Energy, Mines and Resources. Ottawa. 18 p.

Millar, J.B. 1969. Some Characteristics of Wetland Basins in Central and Southwestern Saskatchewan. Saskatoon Wetlands Seminar. Canadian Wildlife Service Report No. 6. Ottawa. pp. 73-101.

Millar. J.B. 1976. Wetland Classification in Western Canada: A Guide to Marshes and Shallow Open Water Wetlands in the Grasslands and the Prairie Provinces, Canadian Wildlife Service Report No. 37, Ottawa. 38 p.

Rees, W.E. 1977. The Canada Land Inventory in Perspective. Canada Land Inventory Report No. 12. Environment Canada. Ottawa. 40 p.

Rubec, C. 1980. Wetlands Near Urban Centres Canada. Canada Committee on Ecological Land Classification Newsletter No. 9: 2-3. Ottawa.

Smith, A.D., E.J. Hudgins and M. Spence. 1981. Wetlands Inventory and Evaluation in the Maritimes. Ontario Wetlands Conference Proceedings, ed. by A. Champagne, Federation of Ontario Naturalists. Toronto, Ontario. 116-119.

Snell, E. 1981. An Approach to Mapping the Wetlands of Southern Ontario. Proceedings of a Pre-Conference Session of the Ontario Wetlands Conference. ed. by M.J. Bardecki: Occasional Paper of the Department of Applied Geography, Ryerson Polytechnical Institute. Toronto, Ontario. pp. 1-26.

Snell, E. 1982. Uses, Abuses and Excuses of the Wetland Mapping Series. Unpublished.

Environment Canada. Burlington, Ontario. 25 p.

Tarnocai, C. 1979. Canadian Wetland Registry. Proceedings of a Workshop on Canadian Wetlands, ed. by C.D.A. Rubec and F.C. Pollett, Environment Canada, Ecological Land Classification Series No. 12. Ottawa. pp. 9-38.

Warren, C.L. and P.C. Rump. 1981. The Urbanization of Rural Land in Canada: 1966-1971 and 1971-1976. Land Use in Canada Series No. 20. Environment Canada. Ottawa. 283 p.

Zoltai, S.C. 1979. An Outline of the Wetland Regions of Canada. Proceedings of a Workshop on Canadian Wetlands, ed. by C.D.A. Rubec and F.C. Pollett. Environment Canada. Ecological Land Classification Series No. 12. Ottawa. pp. 1-8.

APPENDICES

Appendix I
A Summary of CLI Soil Capability Classification for Agriculture

SUMMARY OF
SOIL CAPABILITY CLASSIFICATION FOR AGRICULTURE

The agricultural capability inventory provides information, in the form of maps and statistical tables, on the location, quality and extent of land suitable for the production of annual field crops, forage, improved pasture and native grazing. The data are used at municipal, provincial and national levels for planning the efficient use of agricultural resources. The information is particularly useful to delineate agricultural lands, identify submarginal farmland, consolidate farms into viable units, establish an equitable assessment base and indicate where urban and industrial expansion might take place without unduly reducing agricultural production.

The capability inventory is based on the interpretation of the data provided by systematic soil surveys, generally at the scale of one or two inches to the mile. Through interpretation, the soils are ranked.

In this classification, on the basis of soil survey information, mineral soils are grouped into seven classes. Soils in Classes 1, 2, 3 and 4 are considered capable of sustained use for cultivated field crops; those in Classes 5 and 6 only for perennial forage crops, and those in Class 7 for neither.

Important criteria on which the classification system is based are:

- Soils will be well managed and cropped, using a largely mechanized system;
- Land requiring improvements (including clearing) that can be made economically by the owner is classed according to its limitations or hazards in use as if the improvements have been made. Land requiring improvements deemed beyond the means of the individual owner is classed according to its present condition.
- These factors are not condidered: distances to market, type of roads, location, size of farms, type of ownership, cultural patterns, skill or resources of individual operators, and hazard of crop damage by storms.

The classification does not include capability of soils for trees, tree fruits, small fruits, ornamental plants, recreation, or wildlife.

The classes are based on intensity rather than the type of agricultural limitations they display. Each class includes many kinds of soils, and many of the soils in a class need different management and treatment.

CLASSES

1 - SOILS IN THIS CLASS HAVE NO SIGNIFICANT LIMITATIONS IN USE FOR CROPS

The soils are deep, are well to imperfectly drained, hold moisture well, and in the virgin state were well supplied with plant nutrients. They can be managed and cropped without difficulty. Under good management they are moderately high to high in productivity for a wide range of field crops.

2 - SOILS IN THIS CLASS HAVE MODERATE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE MODERATE CONSERVATION PRACTICES

The soils are deep and hold moisture well. The limitations are moderate and the soils can be managed and cropped with little difficulty. Under good management they are moderately high to high in productivity for a fairly wide range of crops.

3 - SOILS IN THIS CLASS HAVE MODERATELY SEVERE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE SPECIAL CONSERVATION PRACTICES

The limitations are more severe than for Class 2 soils. They affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. Under good management they are fair to moderately high in productivity for a fair range of crops.

4 - SOILS IN THIS CLASS HAVE SEVERE LIMITATIONS THAT RESTRICT THE RANGE OF CROPS OR REQUIRE SPECIAL CONSERVATION PRACTICES, OR BOTH

The limitations seriously affect one or more of the following practices: timing and ease of tillage; planting and harvesting; choice of crops; and methods of conservation. The soils are low to fair in productivity for a fair range of crops but may have high productivity for a specially adapted crop.

5 - SOILS IN THIS CLASS HAVE VERY SEVERE LIMITATIONS THAT RESTRICT THEIR CAPABILITY TO PRODUCING PERENNIAL FORAGE CROPS, AND IMPROVEMENT PRACTICES ARE FEASIBLE

The limitations are so severe that the soils are not capable of use for sustained production of annual field crops. The soils are capable of producing native or tame species of perennial forage plants, and may be improved by use of farm machinery. The improvement practices may include clearing of bush, cultivation, seeding, fertilizing, or water control.

6 - SOILS IN THIS CLASS ARE CAPABLE ONLY OF PRODUCING PERENNIAL FORAGE CROPS AND IMPROVEMENT PRACTICES ARE NOT FEASIBLE

The soils provide some sustained grazing for farm animals, but the limitations are so severe that improvement by use of farm machinery is impractical. The terrain may be unsuitable for use of farm machinery, or the soils may not respond to improvement, or the grazing season may be very short.

7 - SOILS IN THIS CLASS HAVE NO CAPABILITY FOR ARABLE CULTURE OR PERMANENT PASTURE

This class also includes rockland, other non-soil areas, and bodies of water too small to show on the maps.

O - ORGANIC SOILS (Not placed in capability classes)

SUBCLASSES

Excepting Class 1, the classes are divided into subclasses on the basis of kinds of limitation. The subclasses are:

C - Adverse climate - The main limitation is low temperature or low or poor distribution of rainfall during the cropping season, or a combination of these limitations.

D - undesirable soil structure and/or low permeability - The soils are difficult to till, absorb water slowly or the depth of the rooting zone is restricted.

E - erosion damage - Past damage from erosion limits agricultural use of the land.

F - fertility - Low natural fertility due to lack of available nutrients, high acidity or alkalinity, low exhange capacity, high levels of calcium carbonate or presence of toxic compounds.

I - inundation - Flooding by streams or lakes limits agricultural use.

M - moisture - A low moisture holding capacity, caused by adverse inherent soil characteristics, limits crop growth (not to be confused with climatic drought).

N - salinity - The soils are adversely affected by soluble salts.

P - stoniness - Stones interfere with tillage, planting, and harvesting.

R - shallowness to solid bedrock - Solid bedrock is less than three feet from the surface.

S - soil limitations - A combination of two or more subclasses D, F, M, and N.

T - adverse topography - Either steepness or the pattern of slopes limits agricultural use.

W - excess water - Excess water, other than from flooding, limits use for agriculture. The excess water may be due to poor drainage, a high water table, seepage or runoff from surrounding areas.

X - minor cumulative limitations - Soils having a moderate limitation due to the cumulative effect of two or more adverse characteristics which individually would not affect the class rating. (This subclass is always used alone and only one level below the best possible class in a climatic sub-region.)

Appendix II
A Summary of the CLI Capability Classification for 1965-68 Land Use

A SUMMARY OF THE CLI CLASSIFICATION FOR 1965-68 LAND USE

The land use mapping program of the Geographical Branch of the Canada Department of Energy, Mines and Resources and presently the Lands Directorate of Environment Canada has been underway since about 1960. The mapping of land use was done at the scale of 1:50 000 using a uniform nation-wide classification. The program was enhanced by the use of Census of Canada data, aerial photograph interpretation, and other sources of information such as assessment field sheets. The coverage of land use is completed for the entire CLI area dated from 1965-68. Land use data was not be published in map form, but is available as computer mapping inputs at 1:50 000 near cities and 1:250 000 scales across Canada's southern areas. This CLI classification has been replaced by a new land cover/activity system developed by D.M. Gierman in 1983.

PRESENT LAND USE CATEGORIES

Category		Symbol
I	URBAN	
	Land used for urban and associated non-agricultural purposes.	
	1. Built-up area (Parks and other open spaces within built-up areas are included.)	B
	2. Mines, Quarries, Sand and Gravel Pits (Land used for the removal of earth materials.)	E
	3. Outdoor Recreation (Golf courses, parks, beaches, summer cottage areas, game preserves and historical sites.)	O
II	AGRICULTURAL LANDS	
	1. Horticulture, Poultry and Fur Operations Land used for intensive cultivation of vegetables and small fruits including market gardens, nurseries, flower and bulb farms are also included because of their specialized agricultural nature.	H
	2. Orchards and Vineyards Land used for the production of tree fruits, hops and grapes.	G
	3. Cropland Land used for annual field crops: grain oilseeds, sugar beets, tobacco, potatoes, field vegetables, associated fallow, and land being cleared for field crops.	A

Category		Symbol
	4. Improved Pasture and Forage Crops Land used for improved pasture or for the production of hay and other cultivated fodder crops including land being cleared for these purposes.	P
	5. Rough Grazing and Rangeland	K
	(a) Areas of natural grasslands, sedges, herbaceous plants and abandoned farmland whether used for grazing or not. Bushes and trees may cover up to 5 per cent of the area. If in use, intermittently-wet, hay lands (sloughs or meadows) are included.	
	(b) Woodland grazing: If the area is actively grazed and no other use dominates, in some grassy, open woodlands, bushes and trees may somewhat exceed 25 per cent cover.	
III	WOODLAND	
	Land covered with tree, scrub or bush growth, including:	
	1. Productive Woodland Wooded land with trees having over 25 per cent canopy cover and over approximately 20 feet in height. Plantations and artificially reforested areas are included regardless of age.	T
	2. Non-Productive Woodland Land with trees or bushes exceeding 25 percent Crown cover, and shorter than approximately 20 feet in height. Much cut-over and burned-over land is included.	U
IV	WETLAND	
	Swamp, Marsh or Bog Open wetlands, except those which frequently dry up, and show evidence of grazing or hay cutting. (See K Agricultural Lands.)	M
V	UNPRODUCTIVE LAND	
	Land which does not, and will not, support vegetation. e.g. eroded soil or rock and active depositional features.	
	1. Sand (Sand bars, sand flats, dunes, beaches.)	S
	2. Rock and Other Unvegetated Surfaces (Rock barrens, badlands, alkali flats gravel bars, eroded river banks, mine dumps.)	L
VI	WATER	Z

Appendix III
Description of the Test Areas

Description of the Test Area

Manitoba

1) 62I/3 Stonewall - Located northeast of Winnipeg, the map lies within the boundaries of glacial Lake Agassiz on the Red River Plain of the Manitoba Lowlands. It is an area characterized by low relief and lacustrine deposits. Soils are of the Blackearth and Grey Black Zone (Ehrlich et al, 1953).

The original vegetation consisted of permanent marshes of tall marsh grasses and grasslands of tall prairie; meadow prairie and meadow grasses. Virtually all the land area is presently in agriculture, with an emphasis on livestock (Barto et al, 1978).

2. 62K/6 Birtle - The Birtle map sheet is located in the Minnedosa Reston Till plain. The till plain is characterized by low knolls and numerous wetlands called "potholes" or "sloughs". Soils are fertile and of the Blackearth Zone (Ehrlich et al, 1956).

Presettlement vegetation was representative of the Aspen Parkland with mixed prairie grasses, tree ringed depressions of willow, aspen and shrubs and xerophytic plants on the crests of hills (Barto et al, 1978). At present there is growing concern about the conversion of many of the potholes to agricultural uses through draining, infilling and cultivation (Lynch-Stewart, 1983).

3. 63C/3 Swan River - Situated on the Swan River Plain, an extension of glacial Lake Agassiz, the Swan River map sheet is largely comprised of lacustrine deposits of predominantly medium texture overlying till. Topography ranges from gently sloping to level and deeply incised V-shaped ravines are found near the Swan River. Soils are predominantly of the Grey Wooded Zone (Erhlich et al, 1962).

Natural vegetation consists of mixed aspen, birch and poplar stands with black spruce, tamarack and willow with sedges and reeds in the low lying areas. Approximately 60 per cent of the area is presently in mixed farming (Barto and Vogel, 1978).

Nova Scotia

1. 21A/14 Bridgewater - The map sheet includes the three major physiographic zones of Nova Scotia. The North Mountain, Annapolis Valley and the Southern Upland. Both the North Mountain and Southern Upland are rock of Precambrian age that has been overlain by a thin veneer of till. The Annapolis Valley is a complex of lacustrine and

glaciofluvial deposits. Soils of the area are of the Podzol Great Group (MacDougall et al, 1969).

Much of the natural vegetation consists of upland forests of maple, beech and hemlock with balsam fir, black spruce and tamarack with sphagnum mosses in the poorly drained depressions. Agriculture has been practiced in the region since 1604-05 when the first settlers arrived in the area from France. The extensive salt marshes in the Annapolis Valley were dyked during the early settlement period and converted to agriculture. Primary production is now dairy products, fruit and vegetables (MacDougall et al, 1969).

2. 11D/M Musquodoboit - Situated in the Southern Upland Region, the map area is characterized by undulating topography with numerous bedrock knobs and a thin veneer of till. Glaciofluvial deposits of the Musquodoboit Valley are moderately fine textured. Soils of the area are of the Podzol Great Group. Much of the area is still in forest with the exception of the Musquodoboit Valley where dairy and mixed farming are practiced (MacDougall et al, 1963).

Appendix IV
A Table of Quantitative Studies on Monitoring
Land Use Change on Prairie Wetlands
Including References

TABLE QUANTITATIVE STUDIES: IMPACT OF LAND USE CHANGE ON WETLANDS
(Source: Lynch-Stewart, 1983)

Study Area Location and Reference	Study Area Size	Time Period	Land Use Change
Prairies			
.Black Soil Zone of the Prairie Provinces (Goodman and Pryor, 1972)	. 21km^2 pristine wetland within 389 km^2	.1800-1970	. 411 ha (19%) of wetland adversely affected by man-made alterations . 13% net loss of wetland area
Alberta			
.Alberta Aspen Parkland (Schick, 1972)	. 699 km^2	.1900-1970	. 61% net loss of wetland area
.Battle River Basin (Ritter, 1979)	. 301 km^2 of wetland within 11 002 km^2	.1800-1978	. 9% net loss of wetland habitat area . 21% gross loss of wetland habitat area . 7% net gain of wetland habitat area
.South Saskatchewan River Basin (Schmitt, 1980)	. 45 km^2 of wetland within 19 601 km^2	.1800-1979	
Saskatchewan			
.Southern Saskatchewan (Millar, 1981)	. 82 km^2	.1800-1980	. 2,346 (73%) wetland sites affected by transitory impacts . 881 (27%) wetland sites affected by permanent impacts

TABLE QUANTITATIVE STUDIES: IMPACT OF LAND USE CHANGE ON WETLANDS
(Source: Lynch-Stewart, 1983)

Study Area Location and Reference	Study Area Size	Time Period	Land Use Change
Manitoba			
.Newdale Plain (Adams and Gentle, 1978)	. 248 km^2	.1964-1974	. 17% of wetlands altered by clearing or partial drainage . 7% of wetlands eradicated
.Minnedosa Pothole Region (Rakowski et al, 1974)	. 131 km^2	.1964-1974	. 40% net loss of wetland area
.Minnedosa Pothole Region (Kiel et al, 1972)	. 131 km^2	.1928-1964	. 26% net loss of wetland area . 60 (50%) potholes adversely affected by man-made alterations

References for Appendix 4

Adams, G.D., and G.C. Gentle. 1978. Spatial Changes in Waterfowl Habitat, 1964-1974, on Two Land Types in the Manitoba Newdale Plain. Canadian Wildlife Service Occasional Paper Number 38. 29 p.

Goodman, A.S., and S.P. Pryor. 1972. A Preliminary Study of the Methods and Rates of Alteration of Waterfowl Habitat in the Black Soil Zone of Western Canada. Unpublished report prepared for the Canadian Wildlife Service. Edmonton. 77 p.

Kiel, W.H., Jr., A.S. Hawkins, and N.G. Perret. 1972. Waterfowl Habitat Trends in the Aspen Parkland of Manitoba. Canadian Wildlife Service Report Series No. 18. Ottawa, Ontario. 61 p.

Millac, J.B. 1981. Habitat Changes in Saskatchewan Waterfowl Strata 30 to 33 Between Fall 1978 and Fall 1980 - Prairie Waterfowl Habitat Evaluation Program. Canadian Wildlife Service Project Report. 60 p.

Schick, C.D. 1972. A Documentation and Analysis of Wetland Drainage in the Alberta Parkland. Unpublished Report of the Western and Northern Region, Canadian Wildlife Service. 15 p.

Schmitt, K. 1980. Wetland Reconnaissance Within the South Saskatchewan River Basin. Unpublished report prepared for Ducks Unlimited Canada. 29 p.

Radkowski, P.W., R.W. Nero, and R.C. Hutchison. 1974. Present Status of Waterfowl Habitat in the Prime Duck Production Area of Manitoba. Unpublished report prepared for the Canadian Wildlife Service. 12 p.